Instruction Manual 24-78J

For use of the Catalog No. 247800

DIGITAL MICRO-OHM METER

Please read Section 3 - Safety Precautions,
and other Instructions before using this test set.

Biddle Instruments
BLUE BELL, PA. 19422

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INTRODUCTION

The Biddle Catalog No. 247800 Micro-ohm Meter has been specifically designed for the accurate measurement of the very low resistances encountered in electrical distribution, resistance welding, copper bus bars, contactors, cables, crimped joints, bondings etc.

By the use of a high stability voltage to frequency converter and digital integration of its output, stable accurate measurements of resistance can be made over a wide range from 0.1 micro-ohm resolution on the lowest range to 1999 ohms on the highest range.

Low resistance measurements are normally limited in accuracy by the varying thermal e.m.f.'s generated at the lead connections and at the joints in the conductors being measured. The circuit in the Micro-ohm Meter subtracts the effect of both static and varying e.m.f.'s to give a true resistance reading. Lead reversal and reading averaging will be found to be unnecessary with the Micro-ohm Meter.

PRINCIPLE OF OPERATION

The Micro-ohm Meter supplies a constant DC current to the unknown resistance for 0.8 sec. The voltage drop across the resistance to be measured (between the potential leads) is determined. The current generator then turns off for 0.8 sec. during which time the magnitude and slope of the thermal e.m.f.'s are measured and subtracted from the measurement of the voltage drop. The result of this subtraction (calibrated in ohms) is then displayed on the liquid crystal display. The user is not required to operate a switch and subjectively decide when a stable reading has been reached.

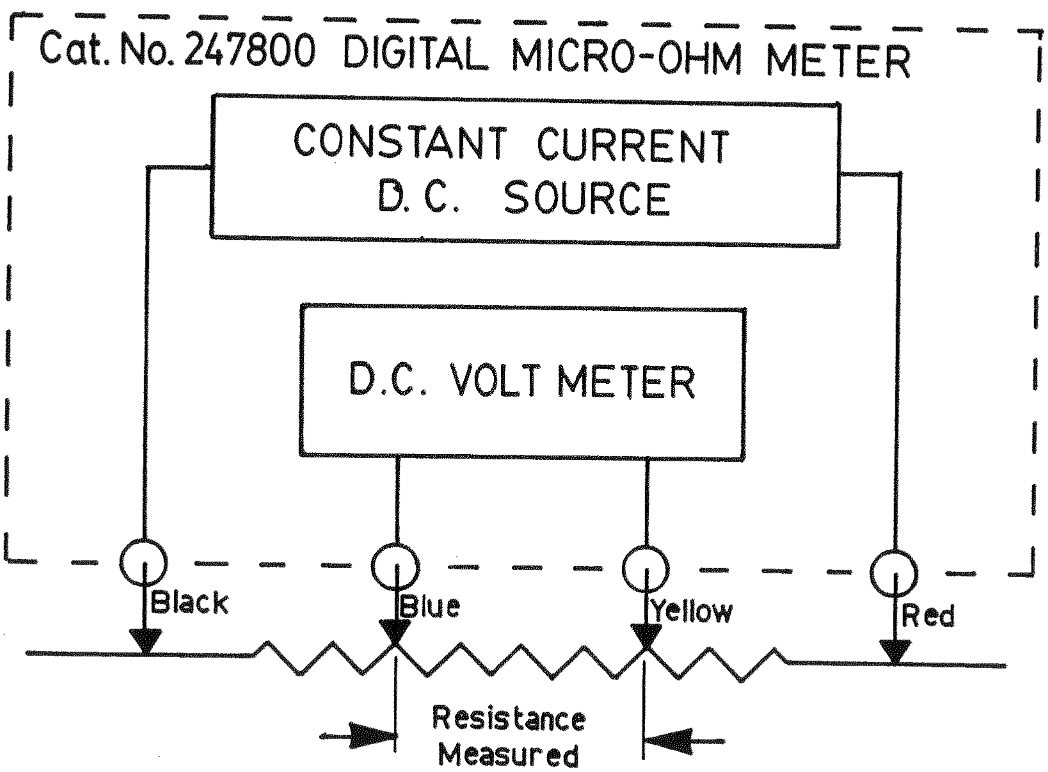


Figure 1-1 Principle of Operation for the Catalog No. 247800 Micro-ohm Meter

SECTION 2

SPECIFICATIONS

Ranges (full scale)	199.9 Micro-ohm to 1999 ohm in 8 decade ranges
Current Through External Circuit	micro-ohm ranges : 1A peak milli-ohm ranges : 0.1A peak ohm ranges : 0.5mA peak
Operations Voltage Limit	2 Volts (minimum)
Indication of Compliance Limit (including open circuit current terminals)	Reading is blanked and "OC" displayed (decimal point and polarity indicator are not blanked)
Battery Power	Internal sealed lead acid (standard)
Battery Life Between Recharges	2½ hours continuous use on micro-ohm ranges. Greater than 30 hours with current leads open circuit.
Battery Indicator	"LO BAT" displayed when approx. 15 minutes of operation remains on the micro-ohm range.
Battery Charger	Built in
Battery Charge Time	Approximately 24 hours for full charge
Reading Rate	1 reading per 1.6 seconds
Display	3½ digit liquid crystal display
Zero	Automatic
Polarity	Automatic, a front colon indicates reverse polarity of the leads.
Thermal e.m.f. Compensation	Automatic for both steady and varying e.m.f.'s
Over Range Indication	Most significant digit displays "1" other digits are blanked. Lead polarity is displayed.
Accuracy (65°F to 82°F)	±(.25% of |reading| + 2 digits)
Lead Reversal Error	± 2 counts (maximum)

GENERAL SPECIFICATIONS

A.C. Power	2 ranges, switch selectable. 105V ac to 130V ac or 210V ac to 250V ac at 50 or 60Hz, 20W max.
Dimensions	8.7 x 3.7 x 9.5" (220 x 95 x 240mm) (case dimensions) dimensions over handle in carrying position : 10.2W x 13.0"D (260 x 330mm)

Instrument Weight	6.2 lbs., (2.8kg)
Shipping Weight	8.8 lbs., (4kg)

ENVIRONMENTAL SPECIFICATIONS

Temperature	32°F to 115°F operating on internal battery power 32°F to 95°F operating continuously on line power -30°F to 140°F storage
Relative Humidity	0 to 80% (no condensation)

OVERLOAD PROTECTION

The instrument is fully protected against voltage spikes when measuring inductive impedences. The instrument will withstand the following voltages at the input terminals without damage:

Current terminal ground (black)
to Potential terminal ground (blue) : ±100V dc

Potential input terminals (blue to yellow) : ±20V dc continuous
±50V dc for 1 second

Current generator input terminals (red to black):

micro-ohm ranges :	±100V dc fuse protected
milli-ohm ranges :	±20V dc for 1 second
ohm ranges :	±20V dc for 1 second

Additional protection is included in the design to limit the damage from high transient voltages.

SECTION 3

USER INSTRUCTIONS AND INFORMATION

SAFETY PRECAUTIONS

- SAFETY IS THE RESPONSIBILITY OF THE USER -

- La seguridad es la responsabilidad del operador -

DO NOT CONNECT THIS INSTRUMENT TO ENERGIZED CIRCUITS!

This Micro-ohm Meter has been constructed to meet the requirements of ANSI C39.5-1974 "Safety Requirements for Electrical and Electronic Measuring and Controlling Instrumentation".

The instrument should only be repaired by trained personnel familiar with the usual precautions for handling line-operated equipment.

Do not use this equipment or any accessories supplied for any purpose not described in this instruction manual.

RECEIVING INSTRUCTIONS

When your Biddle instrument arrives, check the equipment received against the packing list to ensure that all materials are present. Notify Biddle Instruments, Blue Bell, Pa. of any shortage of materials.

Examine the instrument for damage received in transit. If any damage is discovered, file a claim with the carrier at once and notify Biddle Instruments or its nearest authorized sales representative, giving a detailed description of the damage observed.

This instrument has been thoroughly tested and inspected to meet rigid inspection specifications before being shipped. It is ready for use when set up as indicated below.

A qualified person should become familiar with this entire Manual and make a test run. This pre-test serves both to familiarize the user with the test set and to check that the set is operating properly.

SETTING THE A.C. LINE VOLTAGE SELECTOR SWITCH

The ac Line Voltage Selector Switch is located on the rear panel under the fuse holder. It has a recessed actuator to eliminate accidental switching. If the line voltage is between 105V ac and 130V ac move the switch to the left using a small screwdriver or pointed object such as a pencil. If the line voltage is between 210V ac and 250V ac ensure the switch is in the right-hand position. Voltages slightly lower than the above ranges can be used, but may result in a loss of battery charge if the instrument is used for lengthy periods on line power. The battery may also recharge more slowly.

CONTROLS

Figure 3-1 shows the front panel controls and display.

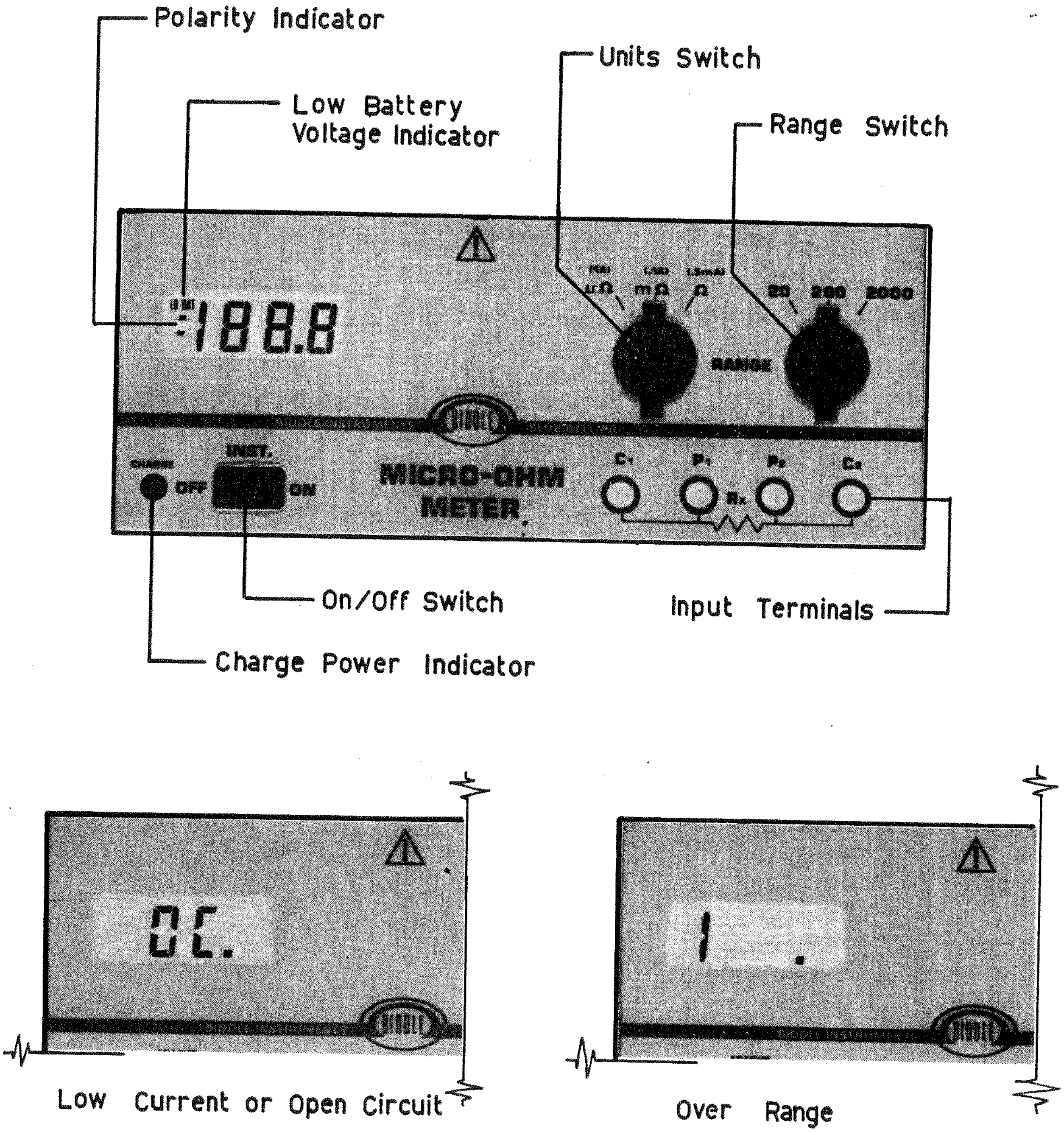


Figure 3-1 Front Panel Controls and Display of the Catalog No. 247800 Micro-ohm Meter

INITIAL CHECK

Rotate the handle to a convenient position by pulling out the handle on both sides of the case.

With the front panel INST switch in the off position plug the power cord into the receptacle located on the rear panel of the instrument. Apply line power to the instrument. The CHARGE light should illuminate to indicate that line power is applied to the instrument and the internal rechargeable batteries are being charged (if necessary).

Turn on the front panel INST switch. The liquid crystal display will be activated and after a couple of seconds the display should read "OC" to indicate the current generator is "open circuit" and no meaningful resistance reading can be obtained. The front colon polarity indicator and the decimal point may also be present.

Connect the lead set supplied to the four 4mm sockets at the bottom right of the instrument. Match the color of the plug on the lead to the color of the socket. Connect the red current clip to the black clip and the yellow potential clip to the blue clip. Switch the RANGE switches to ohms and to 2000. Within a few seconds a reading between :002 and 002 (i.e. :002, :001, :000, 000, 001, 002) should be displayed.

If there are voltage switching transients in the vicinity of the instrument or its leads an occasional reading outside the above range may occur. The colon is the equivalent of a negative sign and is used to indicate reverse connection of the red and black current clips with respect to the yellow and blue potential clips. If the range switch is rotated to the 200 and 20 positions the appropriate decimal point should be displayed. The units switch may also be rotated. On all ranges the reading displayed should be within the range ±2 least significant digits. After changing ranges a few seconds should be allowed for the auto zero circuit to reach stability on the new range.

It should be realized that the leads must be kept stationery. Movement of the potential leads in the earth's magnetic field (and other magnetic fields which may be present) can easily generate the sub micro-volt levels which the potential terminals are measuring on the micro-ohm ranges. It will also be noticed that the least significant digit is blanked when the 20 micro-ohm range is selected. This range is provided due to the front panel design. The 200 micro-ohm range is the lowest effective range, however the 20 micro-ohm range gives accurate valid readings with the same resolution as the 200 micro-ohm range.

To verify the operation of the Micro-ohm Meter, connect a resistor to be measured. The blue and yellow clips are the "potential" clips. The resistance between the blue and the yellow clip is the resistance which will be measured. The red and black clips are the "current" clips. The dc excitation current flows from the red clip through the resistor to be measured to the black (common) clip.

A four terminal resistor or a resistor with long leads should be selected. Connect the yellow and blue clips to the respective potential leads of a four terminal resistor or to each lead close to the body of a normal two terminal resistor. Connect the red current clip to the current terminal associated with the potential terminal connected to the yellow clip and the other current terminal to the black clip. If a two terminal resistor is used connect the red current clip to the lead of the resistor which is connected to the yellow clip with the red clip further away from the resistor body than the yellow clip. Similarly connect the black current clip to the other end of the resistor further away from the resistor body than the blue clip.

Switch on the Micro-ohm Meter and select a range to give maximum resolution of the resistance being measured and note the reading. Interchange the red and black clips (or the red and black 4mm plugs at the front panel) and note that a colon is now displayed in front of the reading. The reading should be within 4 digits of the previous reading.

Select a lower range and note the over range indication which consists of a most significant "1" digit in the extreme left-hand position with the other less significant digits blanked. The polarity indicator and decimal points are still functional. If a much lower range is selected the compliance of the current generator may be exceeded. In this case the over range display will be replaced by the "OC" display.

OPERATING INSTRUCTIONS

DO NOT CONNECT THIS INSTRUMENT TO ENERGIZED CIRCUITS!

1. Ensure that the battery is fully charged by applying line power to the instrument for twenty-four hours or more with the INST switch on the front of the instrument in the "OFF" position. The CHARGE light will be illuminated to indicate that line power is being received. The battery cannot be overcharged within the ambient temperature range of 41°F to 104°F.

2. Connect the leads to the matching color sockets on the front of the Micro-ohm Meter.

3. Isolate the resistances or joints to be measured from their power system. If considered appropriate connect a temporary heavy duty (ground strap) connection to earth. This connection will provide some safety protection against accidental switching on of the power system while taking readings and also will usually improve the stability of the resistance reading. If more than one ground strap connection is used ensure that they do not cause errors in the reading by shunting the resistance being measured.

4. Connect the yellow and blue potential clips respectively to each end of the resistance to be measured. It is important to realize that the resistance measured is the total resistance between the yellow and blue clips. If for example a bus bar joint is being measured then the resistance measured will be the total of the bus bar joint plus the bus bar resistance between the yellow clip and the bus bar joint and the bus bar resistance between the bus bar joint and the blue clip. Consequently if the micro-ohm meter is used for periodic preventative maintenance checks a suitable standard position should be determined for connection of the yellow and blue potential clips. A simple mark on the bus bar will usually be sufficient.

5. Connect the red and black (current) clips outside the yellow and blue potential clips. The spacing of these clips is not critical, however they should be at least three times the maximum width of the conductor away from the closest potential clip to minimize the error due to assymetric current flow. See figure 3-2.

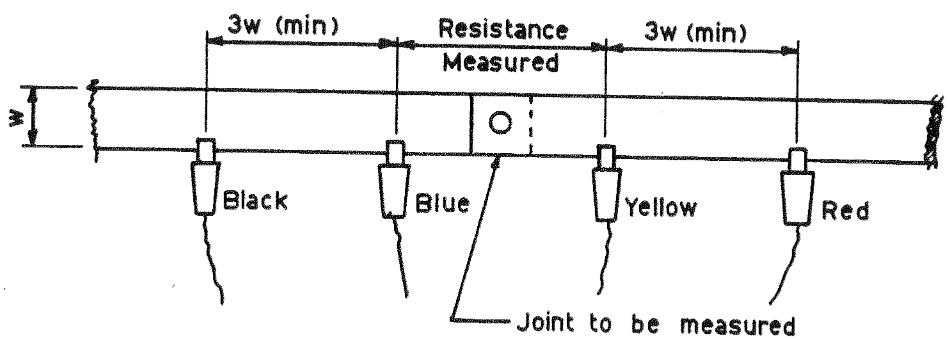


Figure 3-2 Position of Current Clips

6. Turn on the Micro-ohm Meter and adjust the range knobs to obtain a maximum resolution reading. When the appropriate setting has been selected wait a few seconds for the reading to stabilize. If a front colon is displayed this indicates that the potential and current leads are in reverse polarity to each other.

7. The leads should not be moved while a measurement is being made. Movement of the potential leads in the earth's magnetic field can easily generate the sub micro-volt levels which the potential terminals are measuring thus causing errors or unstable readings.

8. After measuring the resistance remove the red clip from the conductor or turn off the micro-ohm meter to conserve the life of the battery.

9. When used on the micro-ohm ranges the battery life is in excess of two hours continuous use. More than 700 readings (10 seconds/reading) can be taken before recharge is necessary. When the "LO BAT" warning appears on the display there is sufficient battery charge remaining for 15 minutes use on the micro-ohms range. The battery will last for more than 20 hours on the milliohms ranges and more than 30 hours on the ohms ranges or on standby, i.e. with the current loop open circuit.

10. To obtain maximum life from the internal lead acid rechargeable battery, recharge the battery as soon as possible after use. Even if the "LO BAT" warning is not displayed it is still advisable to switch off the instrument and connect it to the line to recharge the battery.

11. It should be realized that most conductors have significant thermal coefficients of resistance. For example a copper conductor that has a resistance of 100.0 micro-ohms at 68^{o}F will have increased to 102.0 micro-ohms at 77^{o}F.

12. The liquid crystal display used in your instrument is rugged and reliable. With proper care, it will give you years of satisfactory service. The chemicals that make this advanced type of display possible require certain considerations. To extend the life of the display and to make sure that the display will be ready to operate at a moment's notice, observe the following practices:

    (i) Keep the instrument out of high temperature and high humidity environments such as the dash-board of a car on a hot, sunny day.

    (ii) Keep the instrument out of low temperature environments. Operation or storage at temperatures below -15^{o}C(5^{o}F) may result in the display being sluggish until the instrument is returned to normal operating temperature.

13. Cleaning: Clean the exterior of the instrument with a sponge, and a mild solution of detergent and water.

GENERAL INFORMATION ON TEST LEADS

A standard four clip color coded lead set is supplied.

Specifications: Maximum jaw opening : .78" (20mm)
Overall length : 10 ft (3 meters)

SPECIAL LEADS

General notes to assist the user when assembling special lead sets.

Current Leads

1. Wire type is not critical. It can be either stranded or solid.

2. The maximum lead length allowable will depend on the wire gauge and the range setting. These must be chosen so as to stay within the maximum limit of 2 volts.

   Examples:

Range	Wire Type	Ohms/Ft.	Maximum Overall Length
micro-ohms (1A)	20GA (.032 dia.)	.010	197 ft. (2 ohms)
milliohms (0.1A)	20GA (.032 dia.)	.010	1970 ft. (20 ohms)
ohms (0.5mA)	20GA (.032 dia.)	.010	74.6 miles (4,000 ohms)

Potential Leads

1. Wire type is not critical as the auto zero feature will compensate for thermal e.m.f.'s. Where a choice is available use tinned copper wire.

2. The maximum lead length is practically unlimited as it can be up to 10k ohms resistance. However, long leads will pick up more electrical noise so the practical maximum lead length will depend on the amplitude and type of electrical noise present at the measuring site. The use of shielded potential leads will generally reduce electrical noise pick up.

WARRANTY AND REPAIRS

WARRANTY

All products supplied by Biddle Instruments are warranted against all defects in material and workmanship for a period of one year following shipment. Our liability is specifically limited to replacing or repairing, at our option, defective equipment. Equipment returned to the factory for repair will be shipped prepaid and insured. The warranty does not include batteries, lamps, or tubes, where the original manufacturer's warranty shall apply. WE MAKE NO OTHER WARRANTY.

The warranty is void in the event of abuse or failure by the customer to perform specified maintenance as indicated in the manual.

REPAIRS

Biddle Instruments maintains a complete instrument repair service. Should this instrument ever require repairs we recommend that it be returned to the factory for repairs by our instrument specialists. When returning instruments for repairs, either in or out of warranty, they should be shipped Prepaid and Insured, and marked for the attention of the Instrument Service Manager.

SECTION 4

THEORY OF OPERATION

FUNCTIONAL DESCRIPTION

Figure 4-2 is the functional block diagram of the Cat. No. 247800 Digital Micro-ohm Meter. The time base and control logic turns on the current generator for 0.8 seconds. The voltage across the potential terminals is measured by the analog module using a voltage to frequency converter. After a delay to allow the frequency to stabilize the output of the analog module is accumulated in the counter. When the current generator turns off the analog module is used to measure the voltage at the potential terminals due to thermal e.m.f.'s which are subtracted from the counter. After a delay the auto zero input to the analog module results in the automatic zeroing of the module. The resultant count in the counter is then displayed on the liquid crystal display.

CIRCUIT DESCRIPTION

TIME BASE AND CONTROL CIRCUIT

The time base is derived from a 40.96kHz crystal controlled oscillator IC21a which is buffered by IC21b and then applied to the clock input of a binary divider. A 20.48kHz square wave output SYN is used to drive the inverter for the HR8202 analog module. By gating SYN with the original output in IC21c a clock input is derived for the synchronous decade counters IC32 through IC35. A 40Hz squarewave (BP) is used for the drive to the back plane of the liquid crystal display. IC23 is a divide by eight counter with decoded outputs. Its clock (pin 13) is driven at 5Hz. The outputs of IC23 and the related gates IC24, IC25 and IC26 provide the various control signals required for activating the current generator, the auto zero, the counting system and the display latches. Figure 4-1 gives a timing diagram for one measurement cycle.

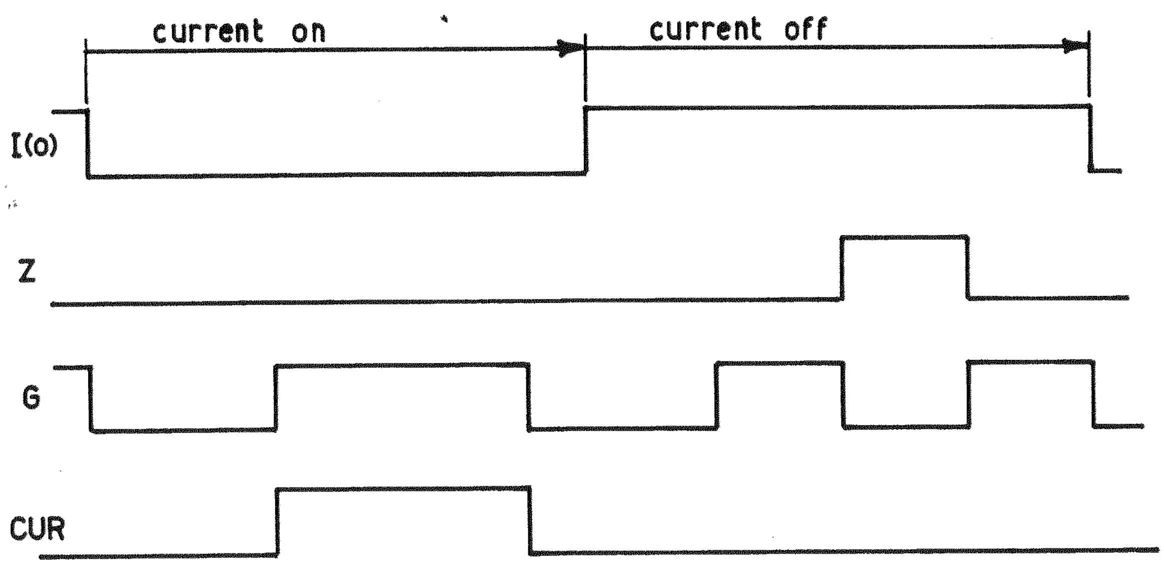


Figure 4-1 Measurement Cycle Waveforms

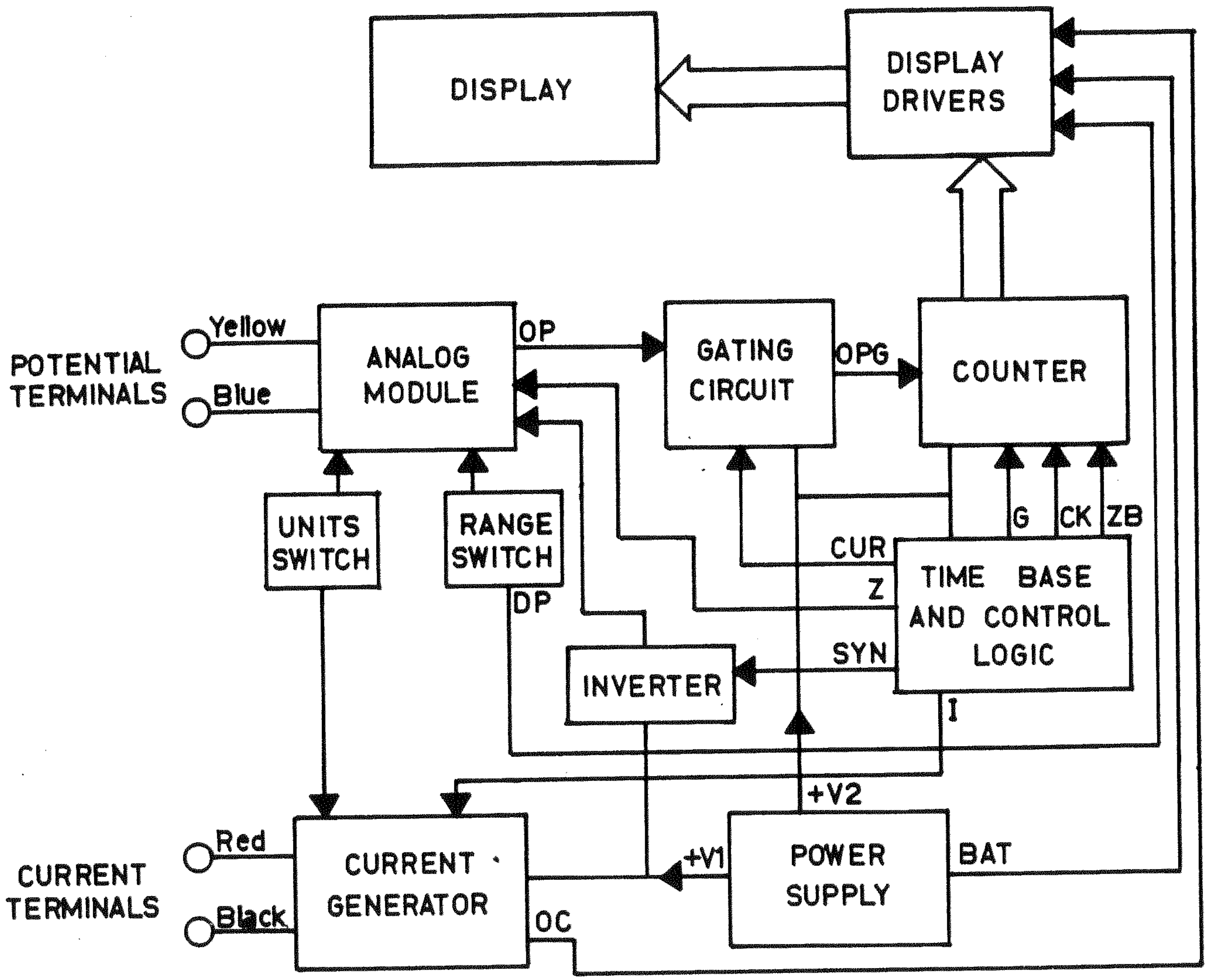


Figure 4-2 Functional Block Diagram of the Catalog No. 247800 Micro-ohm Meter

CURRENT GENERATOR

The current generator is a precision, high compliance generator. The current generator will be described for the 1 amp micro-ohm range. When the digital signal I(o) is high the inverting input (pin 2) of IC6a is at a higher voltage than the non inverting input (pin 3) and thus the output (pin 1, IC6a) is close to zero volts. This means that Q6 will be switched off and so will Q5. Thus no significant current will flow through Q5, R11, D14, F3 and out through the current terminals. With I(o) high Q7 will be switched on which will prevent the small amount of leakage current through Q5 from appearing at the current terminals. When I(o) goes low Q7 will be switched off and the output voltage of IC6a will increase from zero, turning on Q6 which in turn will begin to switch on Q5. The current through Q5 passes through R11, D14 and F3 and through the resistor to be measured between SK3 and SK4. The voltage drop across R11 is measured by IC5. IC5b acts as a voltage follower to minimize the current drawn from the output while IC5a is a difference amplifier which provides an output at pin 7 which is proportional to the voltage drop across R11 and therefore proportional to the current output. The output at pin 7 is referred to analog ground. The output of IC5a provides negative feedback via R25 to the input of IC6a. The precision voltage reference IC6b, IC7 and voltage divider R35, R36, R38 provides a stable reference for the current generator. Thus the output current is held constant over a wide range of resistance to be measured. R17, R19, D11 and D12 provide protection against excessive input voltages.

On the milliohm range the output current flows through R12, R13 and R14 as well as R11. When R14 is properly adjusted the combination of these resistances will be ten times greater than R11 alone, thus providing 0.1A output current. Similarly on the ohms range R15 and R16 are added in series with the output current which reduces it to 0.5mA.

The zener diode D13 provides protection against inductive loads and in conjunction with fuse F3 can also provide some protection if the output is accidentally connected to low voltage live circuits.

The voltage at the collector of Q5 is monitored by the comparator IC6c. If the voltage at the collector of Q5 exceeds 3.7 volts then the output of IC6c (OC(1)) goes high to indicate that the compliance has been exceeded. 3.7 volts at the collector of Q5 is equivalent to about 2.2 volts between the terminals SK3 and SK4. The OC signal from IC6c is stored digitally in the D-type flip flop IC27a and then transferred to IC27b. If the OC signal is high then DOC and ZB go high and $\overline{\text{DOCG}}$ goes low. ZB holds the counter reset while DOC blanks the most significant "1" and converts the tens digit from an "0" to a "C" by inverting the signal to b and c segments of the display with IC42c and IC42b. The $\overline{\text{DOCG}}$ signal blanks the least significant digit. The units and range switches S3c and S4c also activate $\overline{\text{DOCG}}$ via IC24d when the 20 micro-ohm range is selected. This blanks the least significant digit when the 20 micro-ohm range is selected.

Comparator IC6d monitors the battery voltage. If the battery voltage falls below 5.5 volts then the output of IC6d (BAT(o)) goes low. The BAT signal is digitally stored in flip flop IC36b. If the BAT signal from pin 12 of IC36b is high then the "LO BAT" legend on the display is activated by IC42a.

ANALOG MODULE

The analog module EC1 is encapsulated. The epoxy encapsulation protects the sensitive circuits from thermal gradients and other environmental factors which could impair their performance.

The encapsulated circuit is isolated from the current generator ground. Power for the circuit is provided by a 20kHz inverter, IC11, Q11 through Q14 and related components which drive the primary of an encapsulated transformer between pins 1 and 2 of EC1. The auto zero input and the output are coupled via opto isolators.

The input from the potential terminals SK1 and SK2 is filtered by C29, C30, L1 and L2 to reduce the radio frequency content and then applied to the input of EC1 (pin 14 with pin 15 common). R51 is used to provide some protection against excessive input voltages.

The module has an input amplifier followed by a voltage to frequency converter which uses a current balancing technique. The units switch S3d varies the gain of the input amplifier while S3b and S4b vary the current balancing ratios to provide the various ranges. The auto zero input (Z) at pin 7 activates the auto zero circuits to eliminate thermal e.m.f.'s. The output from the module is an opto isolator with the collector of its photo transistor connected to pin 5 and its emitter to pin 4 of EC1. This output is amplified by Q15 and used as an input to the digital circuits. The internal power supply is available for test at pin 8 and pin 9. Pin 8 should be -5V ±0.1V with respect to pin 15 while pin 9 should be +5V ±0.1V with respect to pin 15.

COUNTER

IC32 through IC35 form a synchronous decimal counter. The 20kHz clock input ($\overline{CK}$) is continuously present at pin 15 of all decades of the counter. The count is gated on and off by the G input. IC28c, IC28d and IC31b reverse the direction of counting at zero to provide a standard negative number sequence. The BCD output from the counters along with the sign and over load information is sent to the display drive circuit.

DISPLAY DRIVE CIRCUIT

The display drive integrated circuits IC43, IC44, IC45 latch the parallel BCD information from the counter and then decode it into a form suitable for a seven segment liquid crystal display. The low battery indicator is driven by IC42a. The decimal points are driven by IC41a and IC41b. The most significant digit is driven by IC42d and the polarity indicator (colon) is driven by IC41c.

POWER SUPPLY

The power supply is a conventional full wave rectified linear system using an adjustable three terminal regulator. With line power applied to the Micro-ohm Meter and the INST switch off, the battery receives a voltage limited tapered current charge. When the line power is off, D7 prevents the battery (B1) from discharging. If the Micro-ohm Meter is used on line power, then IC2a adjusts the output of the regulator to approximately 6.7 volts. This ensures that the battery is not discharged while the instrument is being used on line power.

SECTION 5

MAINTENANCE

WARNING

THESE SERVICING INSTRUCTIONS ARE FOR USE BY QUALIFIED PERSONNEL ONLY. TO AVOID ELECTRICAL SHOCK, DO NOT PERFORM ANY SERVICING OTHER THAN THAT CONTAINED IN THE OPERATING INSTRUCTIONS.

CALIBRATION

ACCESS FOR CALIBRATION

Use the following procedure to gain access to the calibration adjustments of your instrument.

1. Set the INST switch to the OFF position and remove the power cord plug from the receptacle in the rear of the instrument.

2. Adjust the handle to be straight out in front of the instrument.

3. Place the instrument upside-down on a flat surface.

4. Remove the four screws which hold the bottom feet.

5. While holding the instrument case together turn the instrument over and place it on a flat surface right way up.

6. Lift off the top cover.

7. All the adjustments necessary for calibration are now accessible.

8. For reassembly, reverse the procedure taking care to fit the front and back panels into the grooves in the top cover. Also take care that no wires are in such a position that they could be pinched or damaged.

Note: To avoid contaminating the printed circuit boards with oil from the fingers handle the circuit boards by their edges or wear gloves.

FUSE REPLACEMENT

The Catalog No. 247800 Micro-ohm Meter has three fuses.

1. There is a 250mA (3AG) Slo Blo Fuse in the A.C. line supply. This fuse is accessible from the outside of the rear panel. To remove the fuse, remove the power cord plug from the receptacle in the rear of the instrument, then push the blade of a small screwdriver into the slot at the top of the fuse holder. The fuse holder cap and the fuse will pop out. The fuse can then be pulled out of the cap. To replace push the fuse into the cap and then push the whole assembly into the fuse holder body until it clips into position.

2. The internal rechargeable battery is protected from excessive discharge rates by a 2 amp standard 3AG fuse located in its positive wire connection. To gain access to this fuse use the access for calibration procedure.

3. The current generator circuit is protected by a 1 amp standard 3AG fuse located on the rear of the display PCB (DM-2A) on the same side as the battery. To gain access to this fuse use the access for calibration procedure.

EQUIPMENT REQUIRED FOR CALIBRATION

1. Certified 4½ digit digital multimeter (Fluke 8050A or equivalent).

2. Precision four terminal resistors. ±.01% accuracy. Resistances required: 1 milliohm, 1 ohm, 10 ohm, 100 ohm and 1000 ohm.

   The above resistors are sufficient to make all calibration adjustments. The following additional resistors will be required to check all ranges: 100 micro-ohms, 10 milliohms, 0.1 ohm.

3. Commercial 5% resistors: 1k ohm, 3.9k ohm.

VOLTAGE REFERENCE

1. Turn on the Micro-ohm Meter.

2. Measure the voltage between pin 2 (+ve) and pin 1 (-ve) of IC7 on the current generator P.C.B. (DM-2B) with the digital multimeter on the 20 volt range.

3. Adjust R37 until the voltage is 2.490 Volts.

BATTERY CHARGER

1. Ensure the INST switch is OFF and the line power is off.

2. Remove the connectors from the battery and connect a 1k ohm resistor in place of the battery.

3. Turn on the line power and measure the voltage across the resistor.

4. Adjust R4 until the voltage is 6.9 Volts ±.05 Volts.

5. Switch on the INST switch at the front panel. The voltage across the resistor should drop to about 6.7 Volts ±0.1 Volt provided the voltage reference has been set correctly.

6. Remove the 1k ohm resistor and reconnect the battery terminals.

CURRENT GENERATOR

The current generator switches on and off on a 1.6 second cycle. For calibration purposes a link is provided to turn on the current generator continuously. This enables the current generator to be calibrated with a normal D.C. multimeter. When calibrating the micro-ohm (1 Amp) range, do not leave the instrument on line power for an extended period as damage to the power transformer may result. The use of battery power is acceptable.

1. Check the common mode rejection of the current generator as follows (steps 2 to 12):

2. Set the RANGE switches to OHMS and to 2000.

3. Connect a digital multimeter on the 2mA range between the red and black front panel sockets.

4. Remove the link connector from the front center of the top horizontal P.C.B. (DM-2B) turn it around and reconnect it. The link will now be on the side towards the battery.

5. Turn on the INST switch.

6. Note the reading on the digital multimeter.

7. Connect a 3.9k ohm resistor in series with the multimeter leads. The reading should be within 0.5 micro-amps of the reading obtained at step 6. If it is not, adjust R21 until the multimeter gives the same reading as noted in step 6.

8. Remove the 3.9k ohm resistor and note the new current reading.

9. Replace the 3.9k ohm resistor and adjust to the reading obtained in step 8.

10. Continue this sequence until the same reading is obtained whether or not the 3.9k ohm resistor is in series with the multimeter.

11. Place a dab of lacquer on the trim potentiometer to lock it in position.

12. Remove the 3.9k ohm resistor in series with the multimeter leads and switch the multimeter to the 2000mA range.

13. Turn the RANGE switch on the Cat. No. 247800 to the micro-ohm range.

14. Adjust R38 on the top horizontal PCB (DM-2B) until the current reading is 1000mA.

15. Turn the RANGE switch on the Cat. No. 247800 to the milliohm range and the multimeter to the 200mA range.

16. Adjust R14 on the rear of the display PCB (DM-2A) until the current reading is 100mA.

17. Turn the RANGE switch on the Cat. No. 247800 to the ohms range and the multimeter to the 2mA range.

18. Adjust R16 (next to R14) until the current is 0.5mA.

19. The current ranges are now calibrated.

20. Replace the link connector in its original position (see step 4) with the link on the side away from the battery.

21. Check that the current is turning on for .8 sec and off for .8 sec (approximately).

ANALOG MODULE

1. Turn the RANGE switches to ohms and to 20.

2. Connect the precision 10 ohm 4 terminal resistor to the Cat. No. 247800.

3. Turn on the INST switch of the Cat. No. 247800 and adjust R64 on the display PCB (DM-2A) to give a reading of 10.00 ohms on the display.

4. Remove the 10 ohm resistor and connect the 100 ohm four terminal precision resistor to the Cat. No. 247800.

5. Turn the RANGE switch to 200 and adjust R66 on the display PCB to give a reading of 100.0 ohms on the display.

6. Remove the 100 ohm resistor and connect the 1000 ohms four terminal precision resistor to the Cat. No. 247800.

7. Turn the RANGE switch to 2000 and adjust R65 to give a reading of 1000 ohms on the display.

8. Remove the 1000 ohm resistor and connect the 1 ohm four terminal precision resistor to the Micro-ohm Meter.

9. Turn the RANGE switch to milliohms and to 2000.

10. Adjust R63 to give a reading of 1000 milliohms on the display.

11. Remove the 1 ohm resistor and connect the 1 milliohm four terminal precision resistor to the Micro-ohm Meter.

12. Turn the RANGE switch to micro-ohms and to 2000.

13. Adjust R62 to give a reading of 1000 micro-ohms on the display.

14. Calibration is now complete.

15. If other precision resistors are available a check of all the ranges and linearity can be made.

REPAIRS AND TROUBLESHOOTING

Many of the circuits use C-Mos logic. It is essential to use a grounded soldering iron and take the standard precautions against damage by static charges. When troubleshooting your Micro-ohm Meter never remove, install, or otherwise connect or disconnect components without first setting the INST switch to the OFF position and removing the line cord. For major disassembly it is also wise to disconnect the battery terminal or battery fuse.

PRINTED CIRCUIT BOARD (PCB) ACCESS

To gain access to the printed circuit boards first complete the access for calibration procedure.

DISPLAY PCB

To gain access to the display PCB (DM-2A) remove the side panels along with the handle. With a small screwdriver gently and evenly pry out the flat cable connectors. Remove flat cable connectors SK5 and SK6 from behind the display and SK7 from the upper horizontal PCB (DM-2B). The front panel and display PCB assembly may now be lifted out of the slot in the bottom of the case and laid face down in front of the rest of the instrument. In this position the analog module HR8202 may be readily removed by undoing its retaining clip and unplugging it from its connector. Take care to remove the module evenly all round to avoid bending its connecting pins.

REMOVING THE DISPLAY PCB

To remove the display PCB from the front panel:

1. Remove the screw through the PCB near the INST switch.

2. Remove the caps from the knobs on the front panel by prying them up with the edge of a blunt knife blade.

3. Position the knobs in the straight up position (200 milliohm range).

4. Using a 9mm socket wrench or "Spin-tite" unscrew the nut in the center of the knob about 1 turn and then pull the knobs off the switch shafts.

5. Using a suitable wrench remove the switch mounting nuts.

6. The front panel can now be swung away from the display PCB providing complete access to the PCB.

7. To ensure the adjustable stops on the rotary switches are not displaced or lost, loosely replace the switch mounting nuts on the switch bush. (The stops should be fitted to position 3).

8. If it is desired to separate the PCB from the front panel then the four wires may be unsoldered from the front panel sockets.

9. The liquid crystal display is fitted in a socket. To remove it pry it up evenly with a soft object. Take care not to scratch the back reflective surface or to crack the glass. To fit a display ensure that all the pins are entered or aligned with the socket then lie the face of the display on a flat, firm, non-scratch surface and press evenly on the back of the PCB to seat the display in its socket. To determine the orientation of the display hold it at an angle to a strong light. The characters and segments will then be faintly visible.

10. Assembly is the reverse of the above procedure.

POWER SUPPLY, CURRENT GENERATOR AND DIGITAL PCB

To remove the horizontal PCB's first remove the display PCB/front panel assembly as detailed under DISPLAY PCB.

1. Remove the four connectors from the power supply and current generator PCB (DM-2B).

2. The dual PCB assembly can now be lifted off its PCB supports.

3. The power supply and current generator PCB (DM-2B) can be separated from the digital PCB by separating the connectors holding the two PCB's together.

4. With these PCB's removed Q5 and IC1 are accessible.

5. Assembly is the reverse of the above procedure.

REMOVING THE BATTERY

To remove the battery remove the side panels along with the handle. Remove the connectors from the battery terminals. Remove the screw, nut and shakeproof washer from the battery clamp. Open up the battery clamp and remove the battery. Assembly is the reverse procedure. Take care not to drop and leave any loose metallic washers or nuts lying on the PCB or in the case.

REMOVING THE ANALOG MODULE (HR8202)

See the heading DISPLAY PCB. When reassembling, ensure that the module retainer is fitted under the spring clip. Omission of the retainer may result in the module coming loose from its connector in service.

Fit the module retainer over the top of the display PCB and the top of the module with the small hole lined up with the hole in the top of the display PCB.

Fasten the spring clip through the hole in the bottom of the display PCB and then lift the other end of the clip over the module and retainer. The end of the spring clip should pass through the hole in the retainer and into the hole in the top of the display PCB. It may be necessary to use a pair of pliers to grip the end of the spring clip and stretch it into position. Figure 5-1 is a diagram illustrating a module mounted on the display PCB.

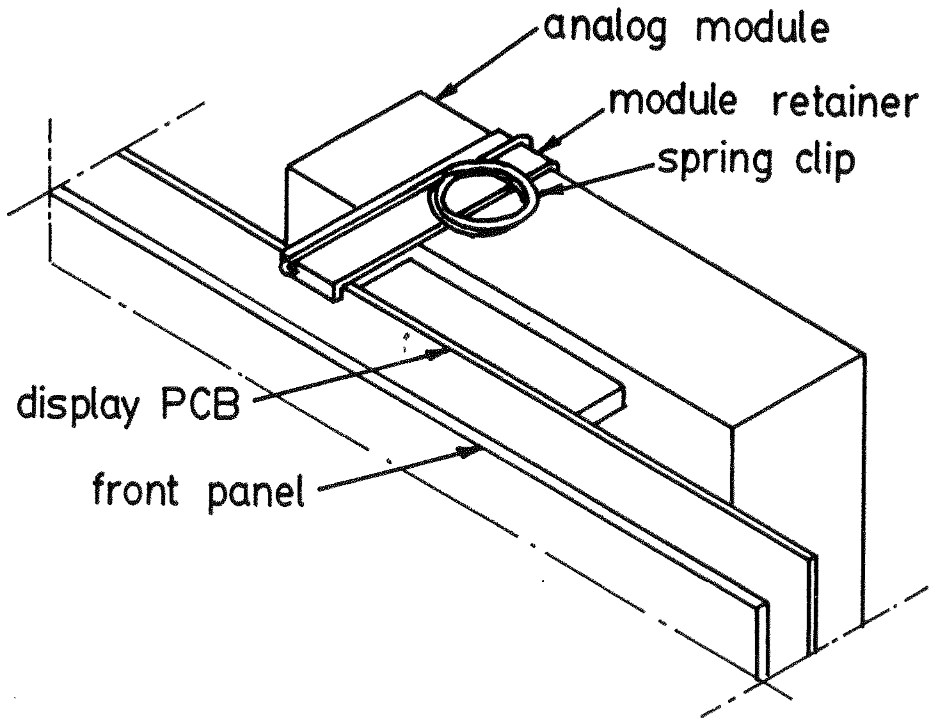


Figure 5-1 Module Mounting

TROUBLESHOOTING

There are four circuits within the instrument which can be tested separately. They are the line power supply, the current generator, the digital circuit and the analog module.

LINE POWER SUPPLY

The line power supply is a standard full wave rectified supply with a three terminal linear regulator. The voltage across C1 should be approximately 16 Volts. For other information see the calibration procedure.

CURRENT GENERATOR

Connect a multimeter across the current terminals (red to black). The current should be observed to be switching on for .8 sec. and off for .8 sec. For other information see the calibration procedure.

DIGITAL CIRCUIT

1. Connect an oscilloscope to the terminal pin in the front corner of the top horizontal PCB (DM-2B) near the battery. Ground the oscilloscope to the black front terminal. The signal should be a clean square wave of 20.48kHz with an amplitude of approximately 5 Volts peak to peak. If not repair or replace the circuits associated with IC21, IC22 and crystal X1.

2. Connect a jumper lead between the red and black terminals on the front panel.

3. Remove the analog circuit block HR8202.

4. Switch on the instrument.

5. The display should display "000" without the front colon after a second or so.

6. With a small clip or test prod connect the OP signal to ground (black front terminal). This is most easily done by connecting the test pin provided at the top center of the front display PCB to ground.

7. The display should display ":000" after a second or so.

The above test is very good proof that the digital circuit is working correctly.

If the above test indicates a fault it is suggested that the analog circuit block remain removed. The logic system will then have a regular series of signals based on a 1.6 second period rather than a random noisy set of signals from the analog input. This will facilitate the measurement of inputs and outputs and logic analysis.

ANALOG MODULE (HR8202)

The analog module is not repairable. Troubleshooting is most easily carried out by replacement with a known good unit.

The circuit diagram shows the expected wave forms with the yellow and blue front panel terminals shorted to each other. The signals will have a 20kHz basic frequency. Ground the oscilloscope to the black front terminal. Pin 2 should be a 20.48kHz square wave with amplitude about .5 Volts less than the battery voltage. The internal power can be checked on pins 8 and 9 with respect to the blue front terminal. The output (OP) can be checked on the test point at the top center of the display PCB (DM-2A) and the OPG signal can be measured on the power supply PCB (DM-2B) near the positive terminal of C1. The OP and OPG signals should be random square/rectangular wave forms of about 5 Volts peak to peak. Measure OP and OPG with the oscilloscope ground referred to the black front terminal.

If the analog module is replaced the ANALOG MODULE calibration procedure will be required.

This completes Section 5.

CAPACITORS

C1	2200uF 35V. Electrolytic
C2	0.022uF 40V. Ceramic
C3	0.022uF 40V. Ceramic
C4	10uF 25V Tantalum
C5	0.027uF 100V. Polyester
C6	0.022uF 40V. Ceramic
C7, C8	10uF 25V Tantalum
C9, C10	not used
C11	0.033uF 100V. Polyester
C12	omit
C13	0.001uF 100V. Polyester
C14	0.1uF " "
C15	0.027uF " "
C16	0.33uF 100V. Polycarbonate
C17	0.027uF 100V. Polyester
C18, C19	0.022uF 40V. Ceramic
C20	not used
C21	0.022uF 40V. Ceramic
C22	10uF 25V. Tantalum
C23	10uF 25V. Tantalum
C24, C25	100pF 100V. Ceramic
C26, C27	10uF 25V. Tantalum
C28	10uF 25V. Tantalum
C29	0.33uF 100V. Polycarbonate
C30	0.1uF 100V. Polyester
C31	0.01uF " "
C32 thru C40	not used
C41	10pF 100V. Ceramic
C42	22pF 100V. Ceramic
C43	0.001uF 100V. Polyester (May require variation to suit IC21)
C44, C45	10uF 25V. Tantalum
C46 thru C50	not used
C51 thru C61	0.022uF 40V. Ceramic
C62 thru C70	not used
C71	.001uF 100V. Polyester
C72	0.022uF 40V. Ceramic

DIODES

D1 thru D7	1N4002
D8	1N914A
D9	BZX79/B5V1
D10	Light Emitting Diode
D11, D12	BZX79/C9V1
D13	BZX70/C12 (or equivalent)
D14	1N4002 (long leads)
D15 thru D18	1N914A
D19	BZX70/C12 (or equivalent)
D20	1N4002
D21, D22	1N914A
D23 thru D30	not used
D31	BZX79/B5V1

INTEGRATED CIRCUITS

IC1	LM317T
IC2	LM358N
IC3, IC4	not used
IC5	LM358N (fitted in socket)
IC6	LM324N
IC7	LM336Z-2.5
IC8, IC9, IC10	not used
IC11	4049UB
IC12 thru IC20	not used
IC21	MC14011BCP
IC22	4020B
IC23	4022B
IC24	4001B

INTEGRATED CIRCUITS (CONT.)

IC25, IC26	4011B
IC27	4013B
IC28	4030B (or 4070B)
IC29, IC30	not used
IC31	4027B
IC32 thru IC35	4029B (or 4510)
IC36	4013B
IC37	4001B
IC38	4011B
IC39, IC40	not used
IC41, IC42	4030B (or 4070B)
IC43, IC44, IC45	4543B
IC46	4013B

RESISTORS

R1	2 ohm 5W. Wire Wound
R2	680 ohm ¼W. Metal Film
R3	not used
R4	1k ohm 1 turn Trim Pot.
R5	10k ohm ¼W. Metal Film
R6	470 ohm ¼W. Carbon Film
R7	56k ohm ¼W. Metal Film
R8a	33k ohm " " "
R8b	omit (trim if required)
R9	68k ohm ¼W. Metal Film
R10	150 ohm ½W. Carbon Film
R11	.47 ohm 5W. Wire Wound
R12	10 ohm ¼W. Metal Film
R13	5.1 ohm ¼W. Metal Film
R14	20 ohm 20 turn Trim Pot.
R15	820 ohm ¼W. Metal Film
R16	200 ohm 20 turn Trim Pot.
R17	68k ohm ¼W. Metal Film
R18	68k ohm " " "
R19	68k ohm " " "
R20	270k ohm " " "
R21	50k ohm 1 turn Trim Pot.
R22	300k ohm ¼W. Metal Film
R23	68k ohm " " "
R24	10k ohm " " "
R25	56k ohm " " "
R26	10k ohm " " "
R27	15k ohm " " "
R28	1.8k ohm " " "
R29	22k ohm " " "
R30	33k ohm " " "
R31	100k ohm " " "
R32	1k ohm " " "
R33	33k ohm " " "
R34	82k ohm " " "
R35	12k ohm " " "
R36	100k ohm " " "
R37	10k ohm 1 turn Trim Pot
R38	20k ohm 20 turn Trim Pot
R39	560 ohm ¼W. Metal Film
R40	100k ohm " " "
R41	200k ohm " " "
R42	68k ohm " " "
R43	10M ohm ¼W. Carbon Film
R44	56k ohm ¼W. Metal Film

RESISTORS (CONT.)

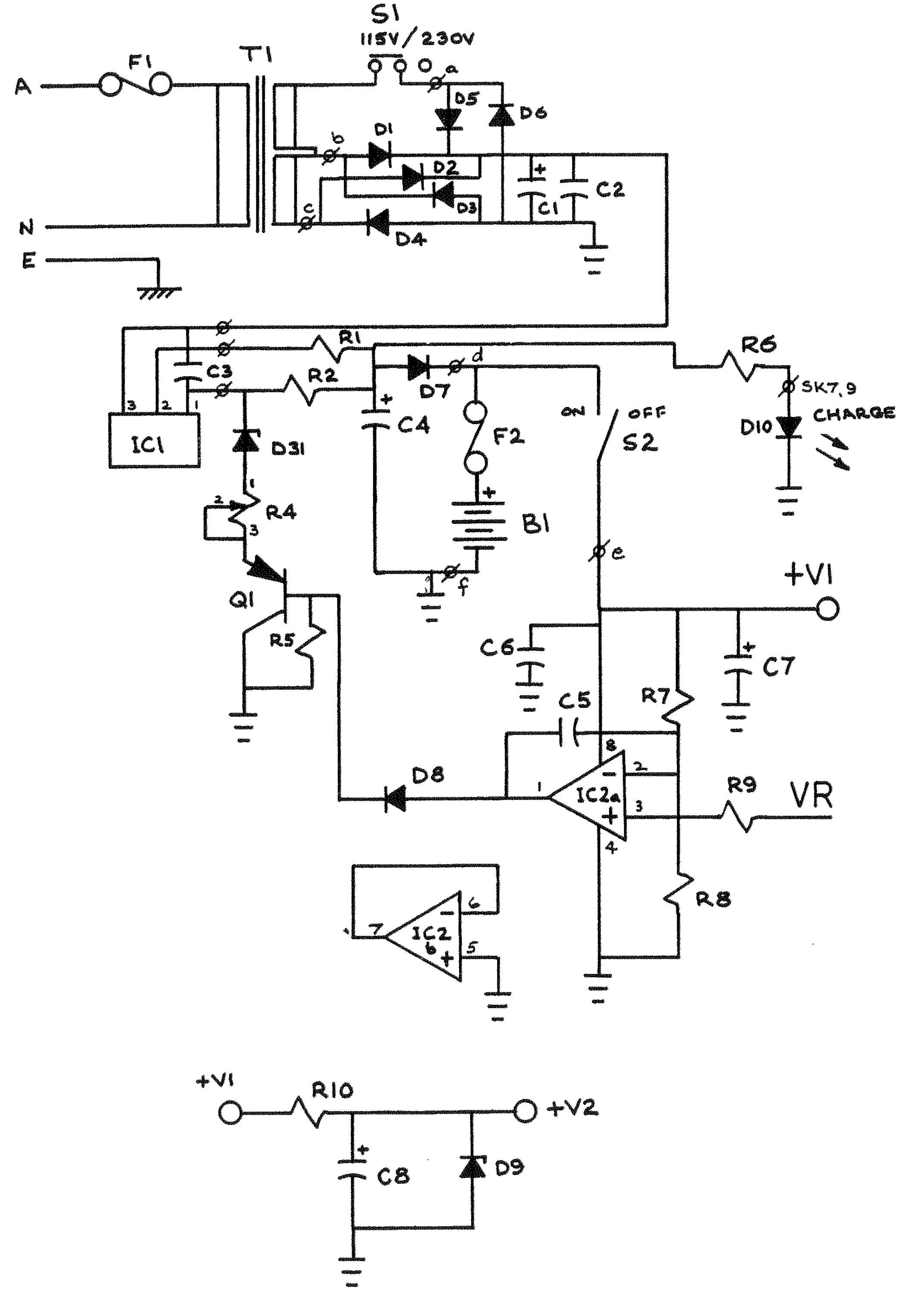
R45	120k ohm ¼W. Metal Film
R46	100k ohm " " "
R47	10M ohm ¼W. Carbon Film
R48, R49, R50	not used
R51	820 ohm ¼W. Metal Film
R52	1k ohm ¼W. Metal Film
R53	120k ohm ¼W. Metal Film
R54	omit
R55	8.2k ohm ¼W. Metal Film
R56	8.2k ohm " " "
R57	8.2k ohm " " "
R58	470 ohm " " "
R59	47k ohm " " "
R60	270k ohm " " "
R61	270k ohm " " "
R62	1k ohm 20 turn Trim Pot.
R63	1k ohm " " " "
R64	1k ohm " " " "
R65	500 ohm " " " "
R66	5k ohm " " " "
R67, R68	4.7k ohm ¼W. Carbon Film
R69, R70	100 ohm " " "
R71	330 ohm " " "
R72	22k ohm ¼W. Carbon Film
R73 thru R80	not used
R81, R82	10M ohm ¼W. Carbon Film
R83	1M ohm ¼W. Metal Film
R84 thru R88	33k ohm ¼W. Carbon Film
R89	not used
R90 thru R94	33k ohm ¼W. Carbon Film

TRANSISTORS

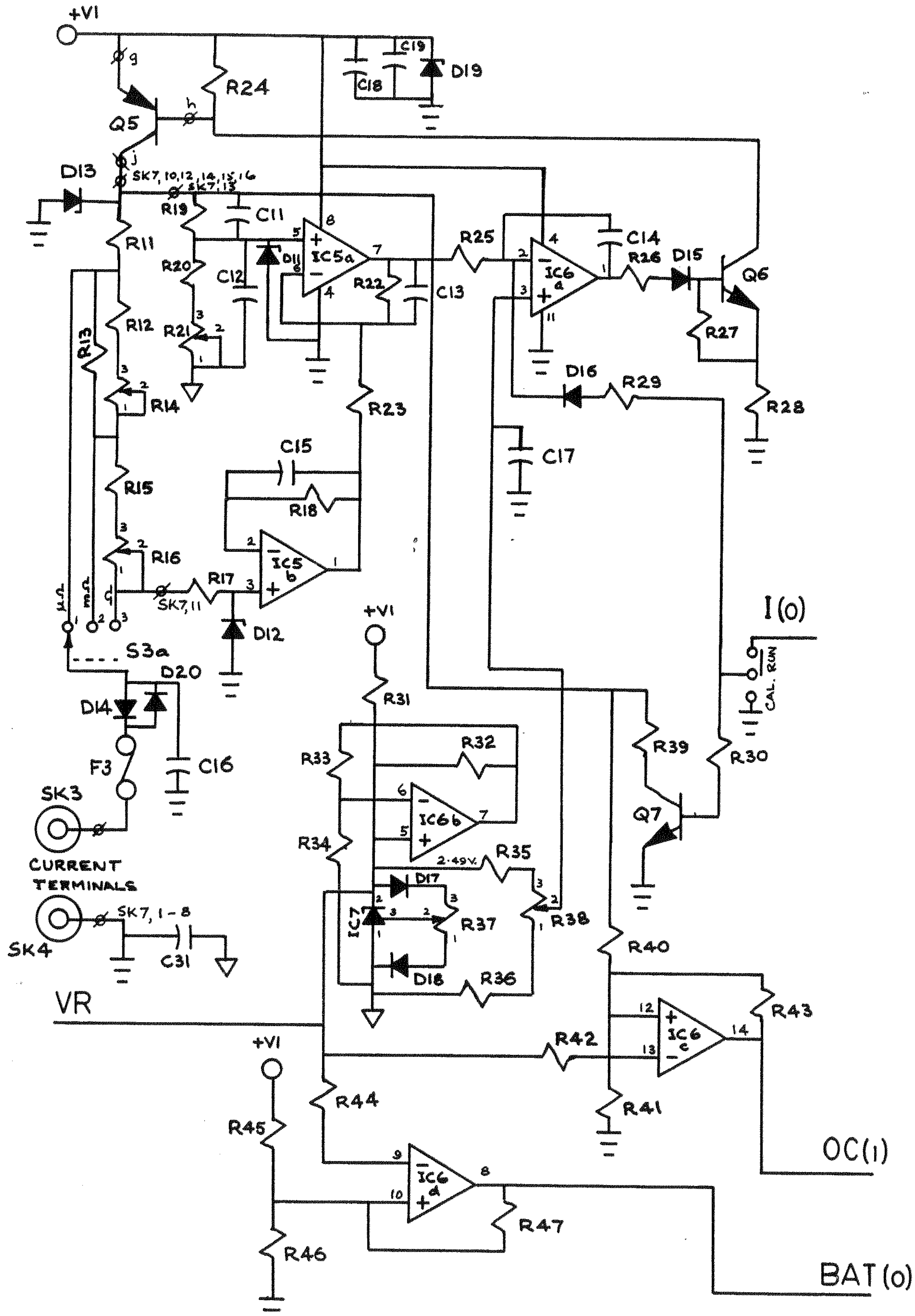
Q1	BC557
Q2, Q3, Q4	not used
Q5	BD678
Q6, Q7	BC547
Q8, Q9, Q10	not used
Q11, Q12	BC547
Q13, Q14	BC557
Q15	BC547
Q16 thru Q20	not used
Q21	BC547

MISCELLANEOUS

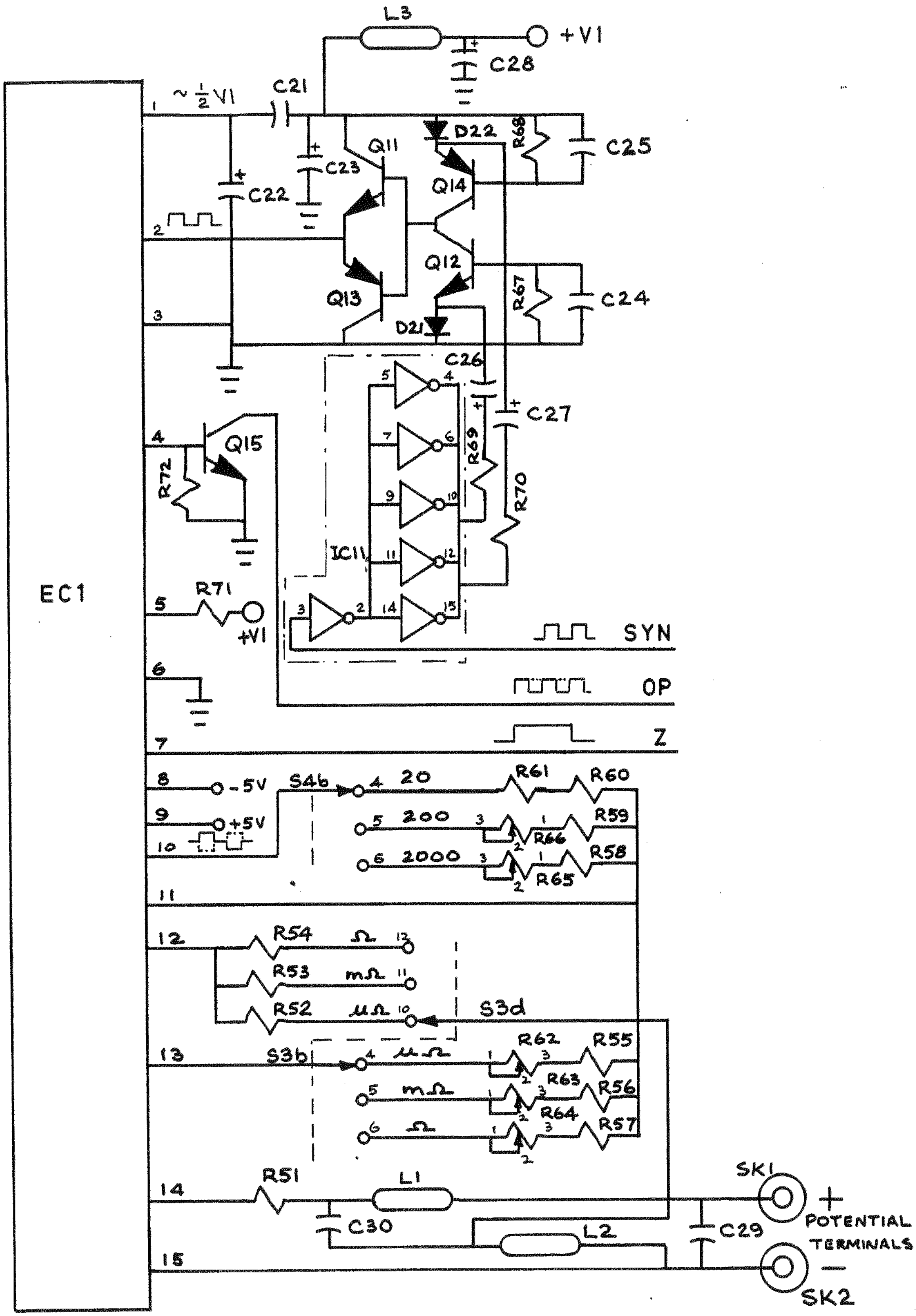
B1	6V 2.6AH Sealed Lead Acid Battery
EC1	HR8202
F1	250mA Delay Fuse
F2	2A Fuse
F3	1A Fuse
L1, L2	Ferrite bead
L3	20uH 100mA Inductor
S1	S.P.S.T. Slide Switch
S2	S.P.S.T. Rocker Switch
S3, S4	4 pole 3 position Rotary Switch
SK1	Yellow 4mm Socket
SK2	Blue 4mm Socket
SK3	Red 4mm Socket
SK4	Black 4mm Socket
T1	Mains Transformer type PL24/20VA
X1	40.96kHz Crystal



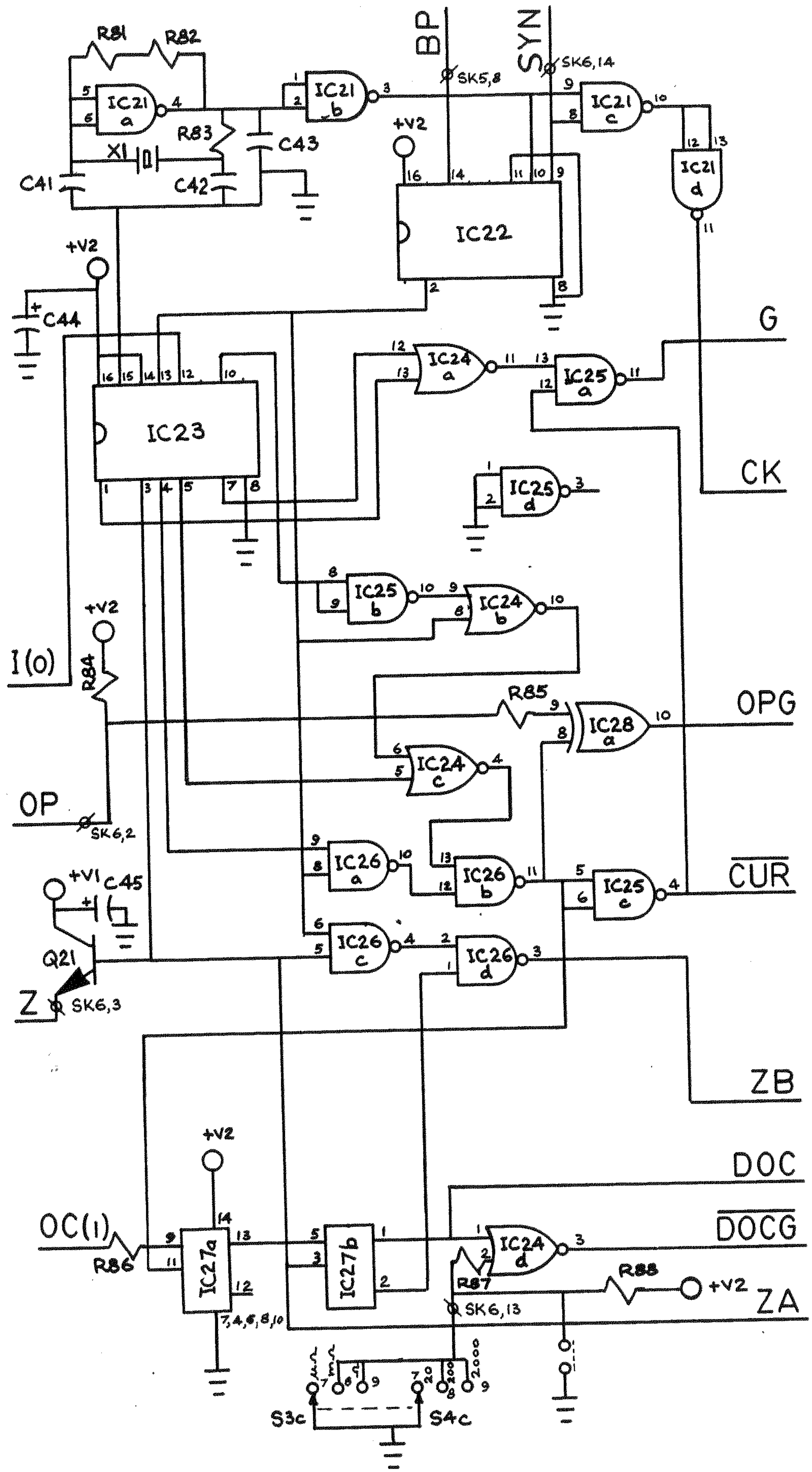
POWER SUPPLY CIRCUIT



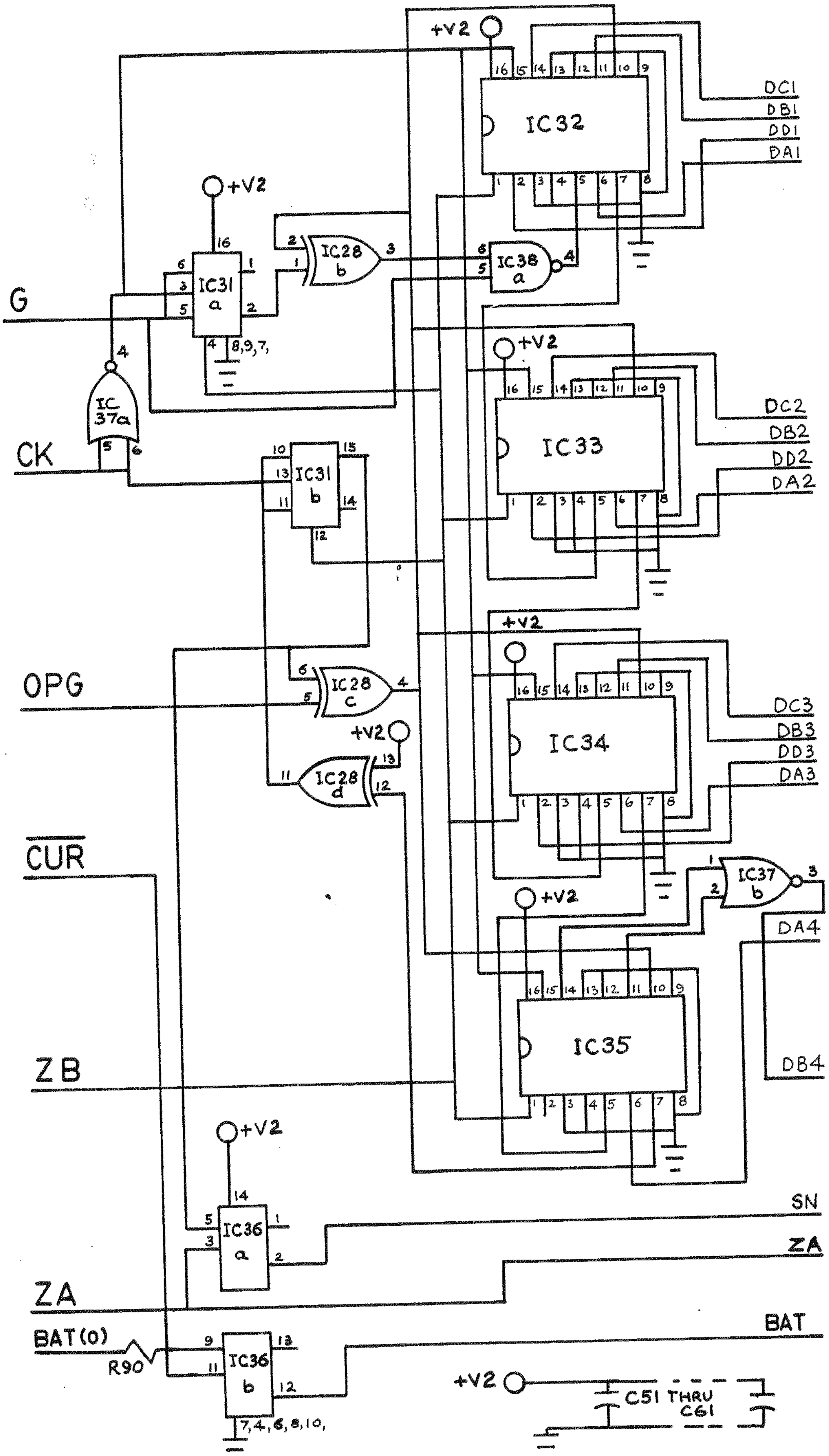
CURRENT GENERATOR CIRCUIT



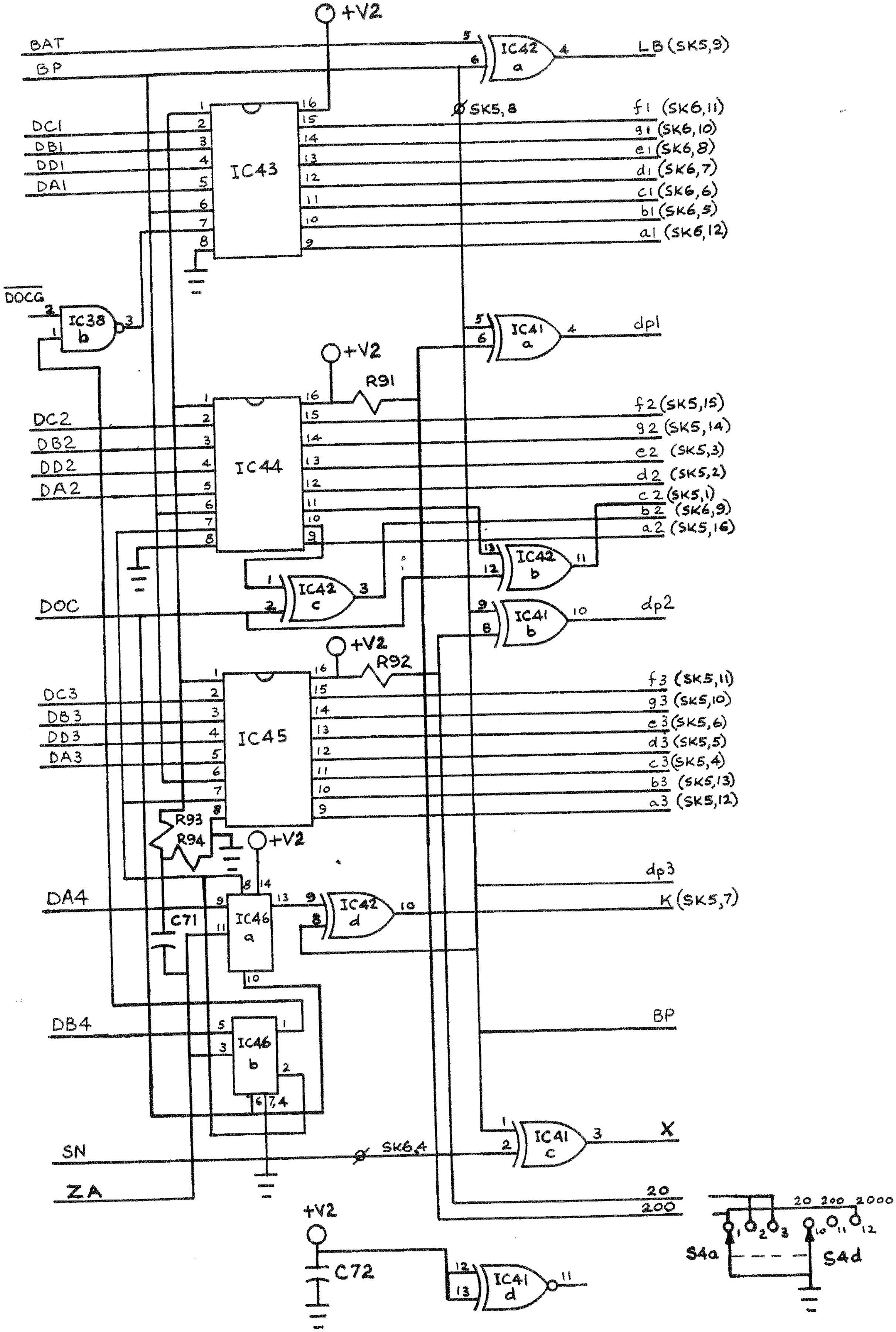
ANALOG CIRCUIT



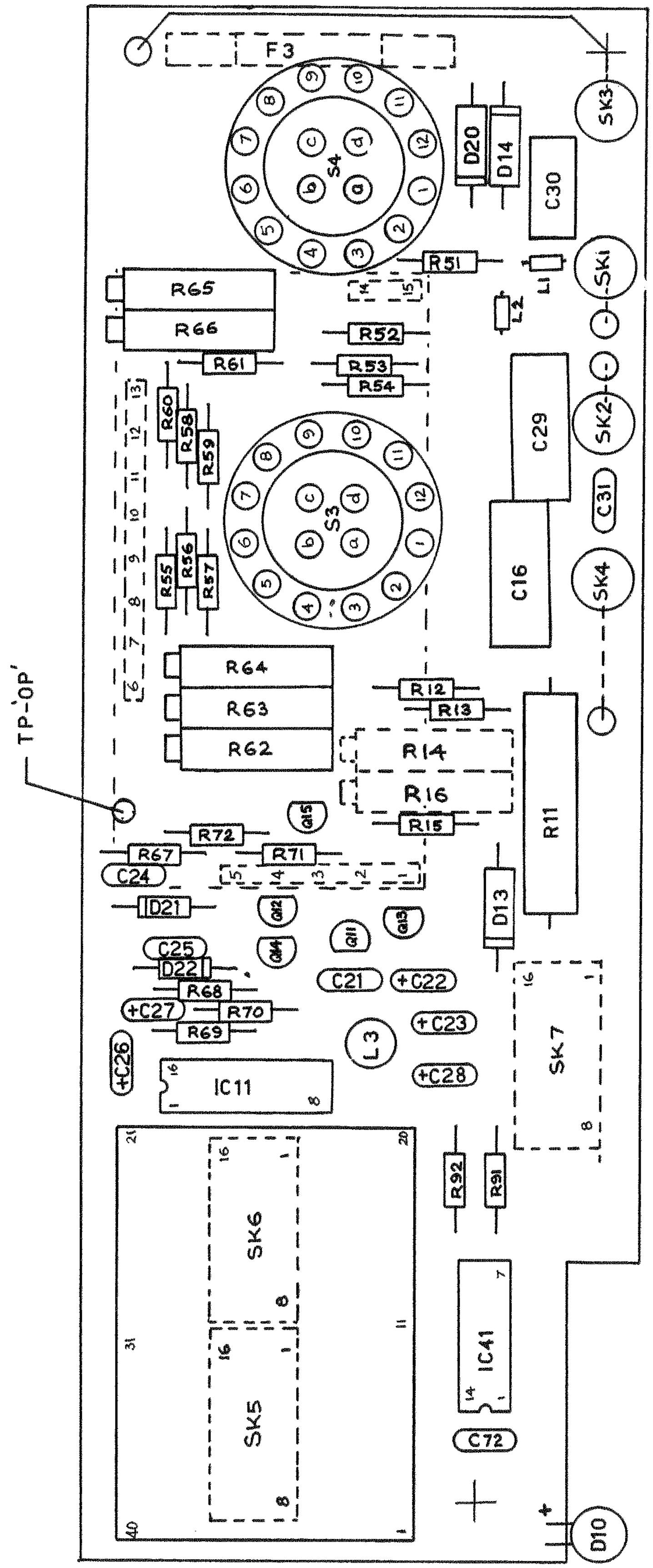
DIGITAL CONTROL CIRCUIT



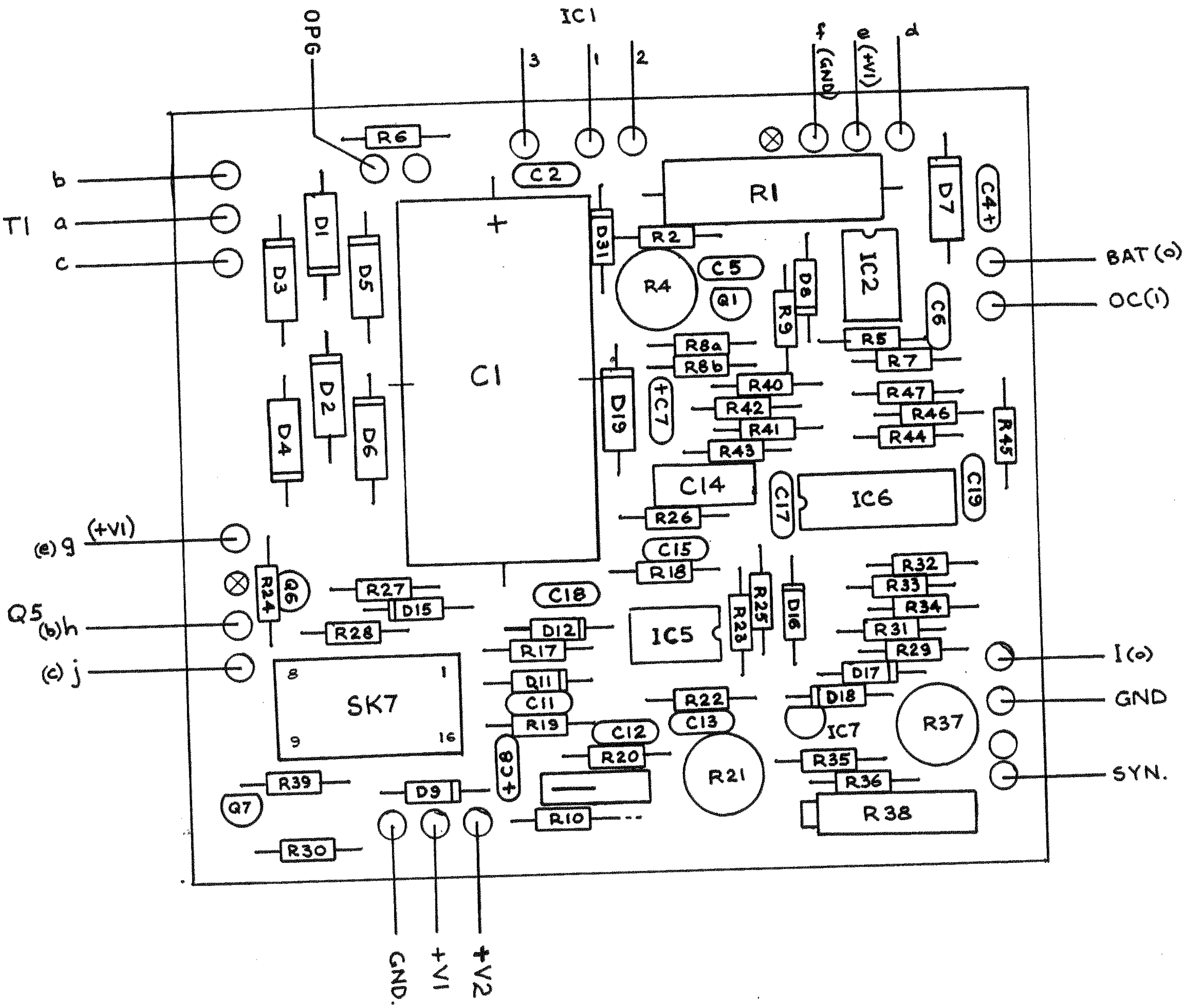
DIGITAL COUNTER CIRCUIT



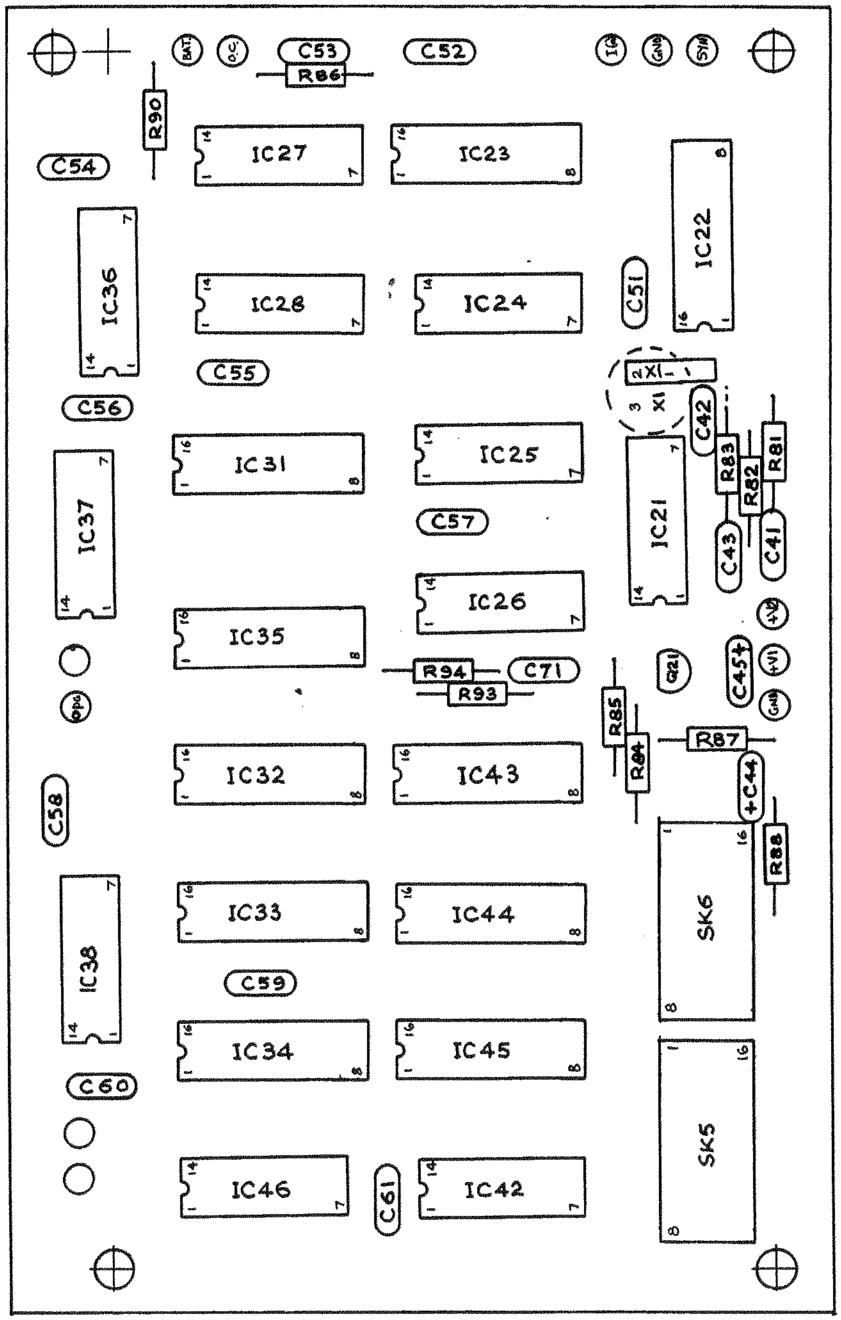
DISPLAY DRIVE CIRCUIT



FRONT PCB LAYOUT



POWER SUPPLY PCB LAYOUT



DIGITAL PCB LAYOUT